



## Modern Clinical Capabilities of Minimally Invasive Manipulations under Ultrasound Control

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**Abstract:** The article presents modern clinical approaches to the use of diagnostic and therapeutic minimally invasive interventions under ultrasound guidance. A list of indications and contraindications for minimally invasive technologies is shown. The tasks of diagnostic, diapaetical and therapeutic minimally invasive interventions are given. The tasks of ultrasound navigation in the local treatment of focal pathology are indicated. A modern classification of minimally invasive instruments and general requirements for the implementation of techniques are given.

**Key words:** minimally invasive interventions, ultrasound diagnostics, ultrasound navigation.

Minimally invasive surgical technologies under the guidance of ultrasound navigation have become the method of choice in the treatment of a number of diseases today. Surgeons, oncologists, specialists in radiation diagnostics, X-ray surgeons, etc. are extremely interested in these technologies. provision of modern surgical clinics. Pathology of the biliary tract, volumetric formations of the abdominal cavity and chest, surgical urology and gynecology - this is an incomplete list of areas of surgery in which minimally invasive technologies in combination with the possibilities of ultrasound topical diagnostics have found their application. The whole process of manipulation consists of two stages: the introduction of a puncture device into the center of the pathological focus and further diagnostic or therapeutic intervention, depending on the specific clinical task. During all these stages, reliable visualization of the target site and the instrument (needle, catheter, etc.) is essential to prevent injuries to organs and blood vessels. These requirements are fully met by the ultrasonic scanning method operating in real time and "gray scale". The method is not burdensome for patients, does not have radiation exposure and is present in the diagnostic departments of almost all types of LPU. Ultrasound scanning, unlike other diagnostic devices, allows: to determine the relative position of organs, taking into account their physiological movement before and during manipulation; choose the optimal puncture trajectory according to the minimum distance to the target focus or the safest path of movement of the puncture device between vital structures; evaluate the entire process of movement of the puncture needle in real time; determine the effectiveness of the manipulation and, if necessary, make adjustments to the process in a minimum period of time; assess the degree of changes in organs and tissues after manipulation in dynamics.

Before an ultrasound examination, laboratory and instrumental data from the patient's medical history are evaluated. Then a clinical examination and methodical palpation of the abdominal organs and the area of minimally invasive intervention are carried out.

The results of ultrasound depend on the correct choice of the mode of operation of the ultrasound machine in relation to a particular patient. The power level and amplification of ultrasonic waves, focusing, image scale, contrast and brightness of the video monitor are important. Otherwise, artifacts arise that make work difficult and lead to erroneous conclusions. Ultrasound devices are tomographs, so they have the disadvantages inherent in tomographs in general. This implies the importance of the professional skill of the researcher who scans the area of interest in full and in all planes. The main technique in all ultrasound techniques is the pendulum swaying of the sensor, which consists in changing the angle of inclination between different scanning planes and the skin surface. In this case, various tomographic sections of the target focus are obtained. The figurative mental summation of the latter gives the operator knowledge about the size, structure of the focus, etc. It is optimal to use three main ultrasound techniques in your work: "gray scale" (B-mode), pulsed wave Doppler according to the program color Doppler mapping and power Doppler (ED). The ED method is more preferable to other color doppler modes, as it displays the state of the vascular system of the focus itself. Pulsed and continuous Doppler studies provide an analysis of high and medium speed indicators in vessels of large and medium diameter around the focus. This mode is necessary in assessing the degree of impact of the pathological process on the surrounding organs and tissues (extravasal stenosis, pathological changes in the walls of the vessel, the dynamics of thrombosis, etc.). The ED method is the most informative in assessing the prevalence of the pathological process: tumor growth into organs and tissues, the presence of metastatic thrombi, the relationship of regional enlarged lymph nodes and small-diameter vessels.

It is optimal to use linear and convex electronic sensors 3.5 and 5.0 MHz, puncture sensor 3.5 MHz. Intraoperative studies are carried out with a linear electronic sensor 7.5–12–15 MHz.

Tasks of ultrasound scanning at the pre-manipulation stage:

1. Preliminary conclusion about the nature of the focus / pathological process.
2. Determination of the optimal route of the puncture channel to the focus/zone of interest.
3. Assessment of the degree of danger of potential complications after manipulation.
4. Selection of a puncture canal ablative program in case of suspected malignant nature of the focus and potential danger of dissemination of malignant cells along the puncture canal or assessment of the need to treat the walls of the puncture canal to prevent bleeding.

Task No. 1 is solved by analyzing the ultrasound image, and after that the doctor - manipulator and / or ultrasound diagnostic specialist selects the biopsy program in accordance with the expected nature of the punctured focus. Problem No. 2 begins to be solved by the B IOPSY program, which is available in devices of almost any class. However, the biopsy "channel" offered by the software of the ultrasound machine is calculated only according to the criterion of the minimum distance from the place of percutaneous insertion of a minimally invasive instrument to the punctured focus. This does not take into account the risk of damage to hollow organs, main vessels, dilated bile ducts, etc. Based on the main principle - minimizing the risk of intervention, the manipulator chooses a safer route for the puncture canal, the issue of the length of the route is secondary. Task No. 3 is closely related to Task No. 2, and a good knowledge of topographic anatomy is required for the entire operating team. If this is expected from a surgeon by definition, then for a specialist in ultrasound diagnostics, the requirements are higher, since classical topographic anatomy is closely related to ultrasound anatomy and topography, which has its own characteristics. Also, a wide range of modern minimally invasive

instruments makes it possible to reduce absolute contraindications and convert them into relative ones. For example, if the puncture of a capillary hemangioma of the liver was contraindicated at the first stages of the diagnostic algorithm in the 1990s due to a high risk of bleeding, then at present fine-needle biopsy (needle G21-22) of hemangiomas is possible according to clinical indications at all stages of this algorithm, which can significantly reduce the economic costs of examining patients. With the same needles, it is safe to carry out multifocal punctures of the pancreas through the walls of the stomach and intestinal loops without the risk of peritonitis.

Tasks of ultrasound scanning during MIM:

1. Holding a minimally invasive instrument in the area of interest.
2. Following a minimally invasive instrument to the area of interest along the previously selected optimal path of the puncture channel.
3. Assessment of the degree of danger of potential complications during manipulation.
4. Confident visualization of a minimally invasive instrument in the area of interest and, if necessary, along the puncture channel.
5. Immediate assessment of the effectiveness of manipulation.
6. Removal of a minimally invasive instrument from the area of interest along the optimal path of the puncture channel with ablastics of the walls of the biopsy channel, if necessary.
7. Identification of immediate complications after MMI.

Tasks of ultrasound scanning after MIM:

1. Evaluation of the effectiveness of manipulation.
2. Identification of early (up to 1-3 days) delayed (from 3 to 15 days) complications after MMI.
3. Assessment of the degree of restoration of the function of the organ and the organ system as a whole.
4. Monitoring to detect long-term complications (from 1 to 3 months).
5. Monitoring to assess the degree of restoration of the function of the organ and organ system as a whole in the long-term period of clinical observation (from 1 to 3 years).

General indications and contraindications for the use of minimally invasive manipulations under ultrasound control.

Indications for MIM are quite extensive and are constantly expanding. They depend on the clinical situation and the availability of other methods of diagnosis and treatment, ranging from traditional (laparoscopy, endoscopy, etc.) to surgical assistance. The task of an ultrasound diagnostic specialist at a preliminary medical consultation is not so much to determine specific indications for MMI in a given patient and the details of the intervention, but to assess the ratio of the risk of this manipulation and its effectiveness in comparison with other diagnostic and treatment methods. The risk of manipulations consists of contraindications to them, anatomical conditions in the area of target organs, the degree of technical equipment, and the professional level of the operator.

The main indications for MIM:

- focal formations of the abdominal cavity and retroperitoneal space (diagnostic punctures);
- pronounced diffuse changes in parenchymal organs with the presence of pseudonodular zones (trepan - biopsy);

- verified tumor formations of malignant genesis (palliative medical manipulations);
- cystic retention formations of parenchymal organs (diapeutic manipulations);
- suspicion of abscesses in the abdominal cavity and retroperitoneal space (diagnostic and therapeutic manipulations);
- jaundice of unknown origin (trepan-biopsy of the liver + PTCG);
- obstructive cholecystitis (diapeutic manipulations);
- mechanical jaundice in cases of: contraindications to ERCP and drugs; decompensation of the cardiovascular system; acute cerebrovascular accident; acute myocardial infarction; coma of various etiologies; in the presence of local contraindications to ERCP and drugs (adhesions, massive infiltrate, pyloric stenosis, operated stomach, PD tumors);
- free or delimited fluid in serous natural cavities of unknown origin.

Contraindications for MIM Absolute:

- decompensated coagulopathy and other diseases accompanied by severe irreversible disorders of the blood coagulation system;
- lack of contact with the patient (acute psychosis, decompensation of mental illness, especially dangerous infections);
- lack of informed consent of the patient to conduct MIM.

Relative:

- a serious condition of the patient (decompensation of diabetes mellitus, pulmonary edema, cardiogenic shock, coma, internal bleeding);
- punctures of echinococcal cysts and hemangiomas with needles more than 1 mm in diameter;
- obstructive jaundice - when carrying out only diagnostic procedures, without further decompression of the bile duct system.

A special place in the expansion of indications is occupied by the presence / absence of local conditions for MIM:

- good visualization of the target organ;
- the presence of a safe trajectory of the puncture channel (the absence of intestinal loops, main vessels, etc.);
- a clear differentiation of the pathological focus from other images similar in ultrasound structure;
- the possibility of performing an emergency surgical intervention in case of complications directly during MMI or delayed procedures.

The absence of these conditions can be regarded as absolute contraindications to minimally invasive procedures.

For a general description of minimally invasive technologies in medicine, we relied on the main standard methods, classifications, indications and contraindications accepted by most researchers and approved by the Association of Ultrasound Diagnostics in Medicine for the period 1998–2009. All minimally invasive manipulations under ultrasound control are divided into four main groups:

Diagnostic

Diapeutic

### Therapeutic

Local therapy ( if ultrasound scanning is the main method of visualization and control)

Below are the tasks and indications for individual groups of interventions.

Tasks of diagnostic minimally invasive interventions:

1. Morphological verification of focal lesions (LP).
2. Cyto - or histological assessment of pathomorphosis after treatment.
3. The need for immunohistochemistry of the OP.
4. Assessment of the flora and sensitivity to AB of the obtained substrate.
5. Intracavitary ultrasound studies.
6. Intravascular interventions.

Indications for diagnostic minimally invasive interventions:

- ✓ OP of malignant genesis;
- ✓ assessment of pathomorphosis after treatment; - OP of a cystic nature;
- ✓ hepatitis, cirrhosis , focal fatty hepatosis , nodular hyperplasia (with the dynamics of ultrasound semiotics);
- ✓ miliary foci (<10 mm);
- ✓ in patients with a primary malignant tumor with the presence of any type of OP;
- ✓ clinical need for cordo - and / or amniocentesis ;
- ✓ the need for the introduction of echo and / or x-ray , MRI contrast;
- ✓ ascites, hydrothorax, effusion pericarditis of unknown etiology.

Tasks of diapueptic / therapeutic minimally invasive interventions:

1. Morphological verification of focal lesions (LP).
2. Assessment of the flora and its sensitivity to AB.
3. Aspiration of the liquid fraction of the OP.
4. Installation of diagnostic/medicinal substances.
5. Transdermal transhepatic cholecystocholangiography .
6. Intravascular punctures/catheterizations, fistulas (eg TIPS).
7. Dosed laparocentesis.
8. Peritoneal dialysis (stage 1 - installation of drains).

Indications for diapueptic / therapeutic minimally invasive interventions:

- retention non-parasitic cysts;
- cysts of any diameter with impaired hemodynamics in perifocal parts of organs or tissues;
- postoperative complications ( abscesses, bile leaks , hemobilema , etc.);
- high biliary hypertension of any origin; - parasitic cysts (if surgical treatment is impossible / inappropriate);



- acute cholecystitis (when surgical or laparoscopic treatment is impossible / inappropriate).

The tasks of minimally invasive interventions in the local treatment of AP:

1. Radical treatment (hepatocellular carcinoma up to 40 mm, retention cysts, growing hemangiomas, adenomas, euthyroid follicular goiter, sclerotherapy of superficial veins, etc.).
2. Palliative / cytoreductive treatment.
3. Palliative care (stopping of visceral pain syndrome).

Methods and indications for minimally invasive technologies in the local treatment of AP:

- sclerotherapy retention cysts of parenchymal organs;
- sclerotherapy of superficial veins;
- Ultrasound monitoring when installing stents in urology, hepatology, pancreatology, etc.;
- Ultrasound monitoring during cryodestruction, radiofrequency ablation, electrochemical lysis, laser destruction of sclerotherapy with ethyl alcohol, etc. malignant focal lesions of parenchymal organs.

(Problems, indications and methods are constantly being improved and updated, at the time of this publication may be increased or changed.)

Tasks of ultrasound monitoring in minimally invasive local treatment of OP:

1. Non-invasive control over the volume of treatment.
2. Assessment of hemodynamics.
3. Selection of areas for informative biopsies.
4. Invasive control of immediate pathomorphosis during treatment.
5. Correction of the technical mode of the local instrumental treatment.
6. Prevention of iatrogenic.

Here are the basic, widely shared data; highly specific methods and tasks that are significant for individual clinical disciplines, we deliberately did not give. Indications and methods are constantly being improved and updated and are subject to change at the time of publication of this publication.

Tools and general rules for the implementation of the methodology: modern requirements

There is currently no generally accepted classification of instruments, but most researchers use the gradation of instruments according to the outer diameter of a minimally invasive device that forms a puncture channel in human tissues (Table 1). The diameter of the needles or drains was measured in millimeters and indicated by the Charrière scale in French (F) units, where  $1F = 0.33 \text{ mm}$ . Needles also vary in gauge (G) gauges. The value of G is inversely proportional to the diameter of the needle. There are the following ratios G, F, inches and millimeters. The most frequent comparisons: G 23 - 0.6 mm, G 22 - 0.7 mm, G 21 - 0.8 mm, G 20 - 0.9 mm, G 19 - 1.0 mm, G 18 - 1.2 mm, G 16 - 1.7 mm, G 14 - 2.1 mm.

**Table 1. Instrumentation for minimally invasive interventions**

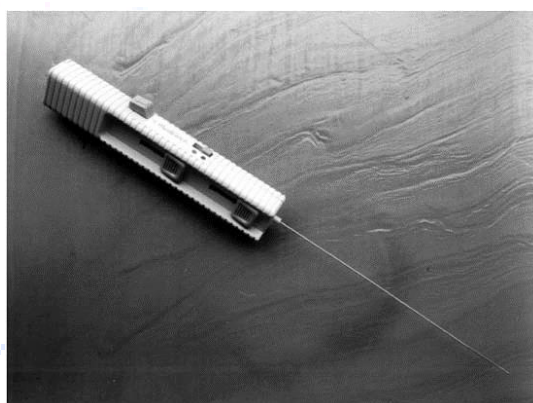
Toolkit category	Outer diameter (nature of the resulting fabric material)	EU classification
Small + needles with a cutting edge	Up to 1 mm (cytology + "small")	G25–G21 (<F3)

	biopsy )	
Average	1.0–1.4 mm (cyto + histology)	G20–G16 (F3–F5)
Large	1.4–2.0 mm (histology)	>G16 (F6)

Notes. G is the diameter of the needle, F is the diameter of the catheter or needle.

Puncture needles differ in the nature of sharpening and the shape of the end of the needle. There are needles with a regular edge of the CHIBA type, needles with cutting edges such as COOK, BAXTER, VYGON, etc. are used. Needles for burr biopsy with a tissue column sampling are more than one millimeter in size. For their work, semi-automatic puncture devices are used, similar to laparoscopic instruments, and the so-called biopsy guns with a full automatic puncture cycle (Fig. 1). For labor-intensive interventions (with PTCG, nephrostomy, endobiliary drainage, etc.), it is advisable to use minimally invasive instrumental kits that include needles of various diameters, bougies, guidewires, and various types of catheters.

To perform MIM, it is necessary to follow the rules of asepsis and antisepsis. Manipulations are carried out in a specially equipped room in the dressing or operating room mode. Sensors are treated with disinfectants based on a solution of chlorhexidine, it is possible to use other means after agreement with the regional SES or the manufacturer of the equipment. It is optimal to use a sterile gel and standard processing of the surgical field, excluding iodine-containing solutions.



**Rice. 1. Automatic device for trephine biopsy**

Free Method hand (free hand) is the simplest, since any ultrasound sensor and a puncture needle that is not connected to the sensor are used. The sensor is installed in the biopsy area and, in free hand movement, the needle is inserted at an angle empirically chosen by the doctor-manipulator during pre-manipulation ultrasound scanning. The method requires a large experience of a minimally invasive team and is reproducible only in those health facilities where MIM has been in practice for several years. The methods of using adapters or puncture probes are similar: there is a rigid sludge and a semi-rigid fixation of the guiding needle to the plane of the probe.

This facilitates the introduction of the end of a minimally invasive instrument into the area of interest, followed by its confident positioning in the area of diagnosis/treatment. The disadvantages of adapters include the presence of the so-called "blind" space, where the needle passes outside the imaging zone. In puncture sensors, the worst visualization of needles less than 1 mm in diameter is observed, since there is an extremely small angle of reflection of echo pulses from the surface of the needle. In adapters, this angle is 2–3 times larger. Stereotactic devices are used less often due to their high cost and narrow range of indications. The main indication is the size of the zone of interest up to 10 mm. This technique is necessary in those health facilities where vascular catheterization is performed under ultrasound control. At the moment, this is the prerogative of angiography, but the cost of the technique

is 10-20 times more expensive than using ultrasound scanning. The composition of the medical team and the nature of anesthesia depend on the nature of the MIM. Thus, the introduction of minimally invasive technologies under ultrasound navigation into modern clinical practice is a necessity in the arsenal of a doctor at the beginning of the 21st century.

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